

Organochlorine Sampling in Watersheds for Rookery Bay NERR Managed Estuaries

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Abstract

Testing of soil from abandoned agricultural fields slated for hydrological restoration demonstrated that residual organochlorine pesticides are still present in varying concentrations. Testing of fields in the Belle Meade and Southern Golden Gates watersheds identified high concentrations of Chlordane (up to 6100 ug/kg) and lower concentrations of DDE, DDD, Dieldrin, and Endosulfan I. The average concentration for non-zero Chlordane sites was 454.01 ± 932.64 , and 62 of 134 samples had concentrations above 3.1 ug/kg. Residual Chlordane was evident throughout the Belle Meade agricultural fields, but high concentrations in Southern Golden Gates Estates appeared to be located at ends of accessible roads. Highest Chlordane concentrations were found in higher field areas, as opposed to ditches and furrows, and there was no correlation between organic soil content and concentration.

Introduction

Organochlorine pesticides were extensively used in agricultural fields after WWII, and it was not until 1987 that EPA legislation banned sales. DDT, Toxiphen, and Chlordane are a few examples of these compounds. Chlordane was also used for termite and fire ant control. Organochlorines are persistent in soil and sediments, but transfer to the water column both as entrained sediment and via adsorption to dissolved organic carbon (Syracuse Research Corporation 1994). At relatively low concentrations, invertebrate populations in both sediment and water are adversely affected. Bioaccumulation has a detrimental impact on vertebrates as well. Chlordane, Toxiphen and DDT derivatives are moderately toxic (Toxicity Category II) while Dieldrin is highly toxic (Toxicity category I) (Pfeuffer 1991).

Agricultural fields no longer in production are repositories for these pesticides. As this real estate is converted to residential or is restored, contaminated soils are often flooded. Remobilization of sequestered pesticides is a potential ecological risk for the estuaries downstream, both in the immediate impact on benthic invertebrates, but also in bioaccumulation as wading birds feed in affected areas. Lake Apopka's flowway marsh is a recent example of an ecological disaster on reclaimed agricultural fields. A mix of residual organochlorines, including Toxiphen, DDT derivatives, Dieldrin and Chlordane may have contributed to the deaths of 800 birds, over 500 white pelicans and 34 wood storks, when wetlands were reconstructed on the north shore of the lake, attracting flocks of wading birds (Pittman 1999, Exponent 2000).

This study was conducted as part of a project modeling flowways through the watersheds affecting estuaries managed by Rookery Bay NERR. Identifying potential ecological risks as these watersheds are developed is an essential tool for resource management. Several agricultural fields in production prior to 1978 in the District VI, Belle Meade and Southern Golden Gates Estates watersheds are now owned by the State of Florida (Figure 1). These are potential areas of restoration with overland sheet flow as a primary goal.

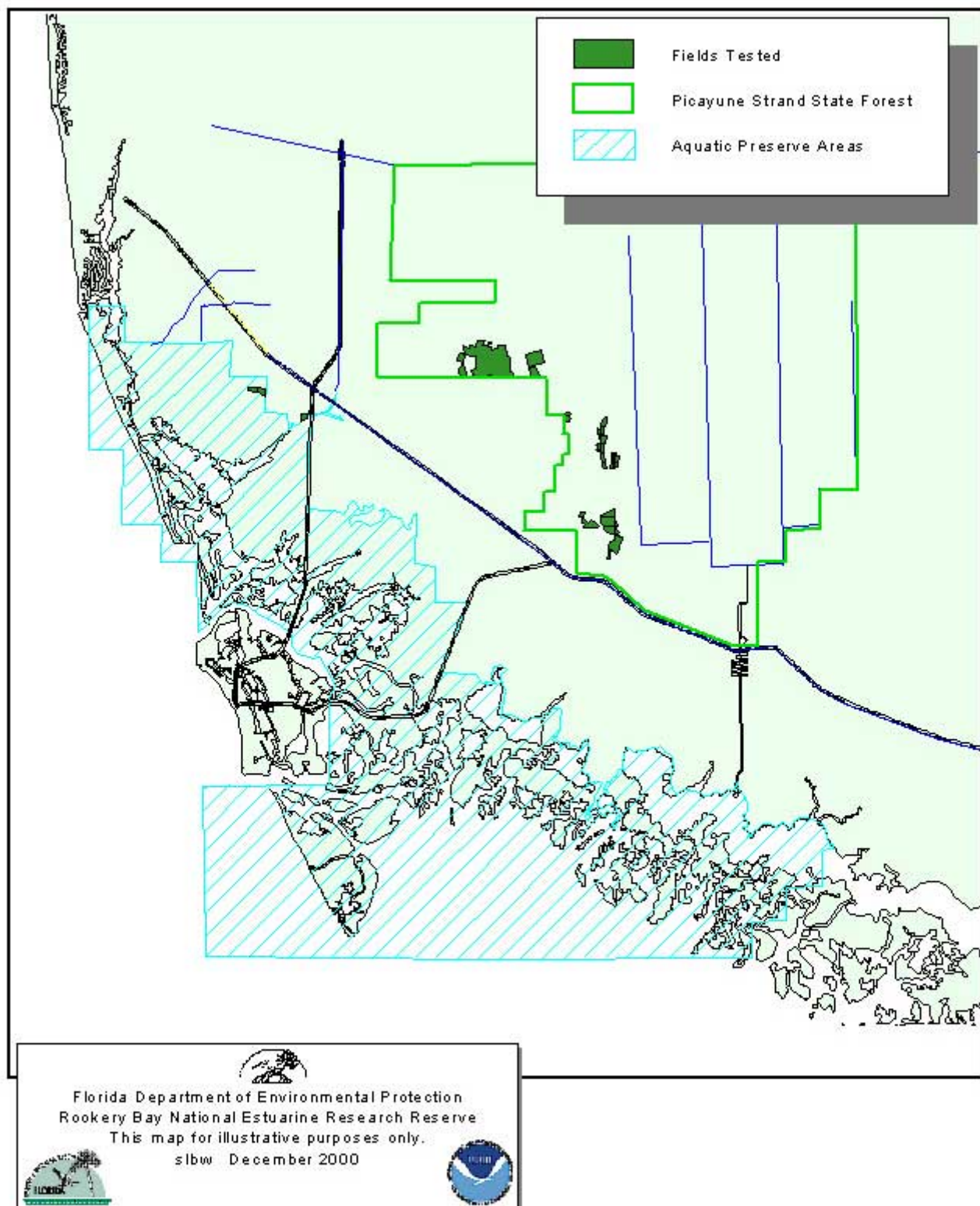


Figure 1. Location of fallow agricultural fields and their relationship to estuary areas managed by RBNERR



a.



b.

Figure 2. USGS digital orthophoto quad map showing furrows in abandoned agricultural fields; a) fields with little shrubby cover; b) fields with extensive Brazilian pepper growth.

Methods

Areas of previous agricultural use were identified from furrow patterns still evident in 1995 using digital orthophoto quadrant images from USGS (Figure 2). Sediments were collected in two separate sampling plans. A total of 134 samples were analyzed, ninety-one in the first set and 43 in the second. The first set was collected over the months of February and March. The second set was collected after review of the results from the first group, in July.

The first collection was randomized over the entire agricultural area available, with the number of sites on each field weighted for percentage of entire area to be tested. Ninety-one samples were also divided between the raised planting areas and the field furrows and ditches. The second collection targeted the areas with significant Chlordane concentrations reported after the first sampling. Sampling was concentrated on raised areas, rather than furrows.

Samples were collected to a depth of 21 cm using a stainless steel auger corer and each individual grab sample was directly transferred to glass jars. The resulting core hole was scraped with a stainless steel trowel from top to bottom, top vegetation removed, and the soil transferred to Ziploc bags for organic content analysis. All equipment coming into contact with samples was stainless steel, and was cleaned between grabs with a phosphate free detergent and multiple isopropyl/DI water rinses.

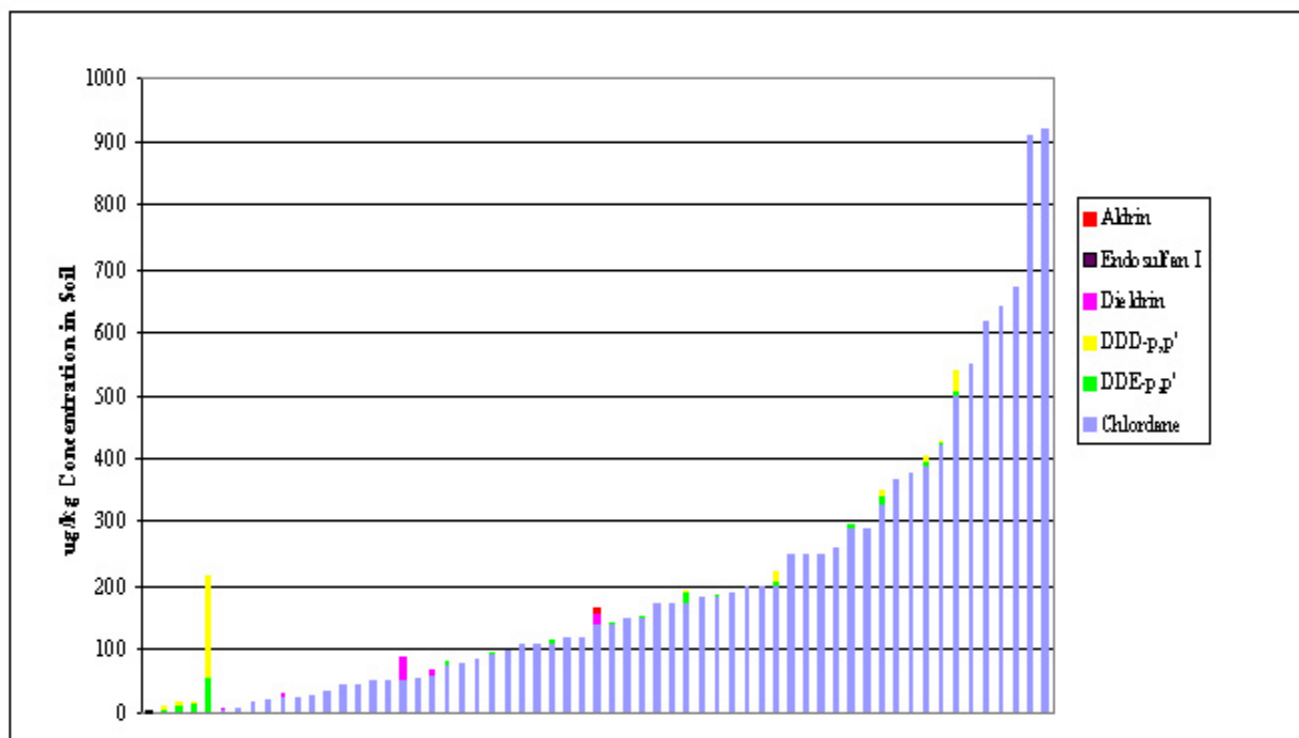
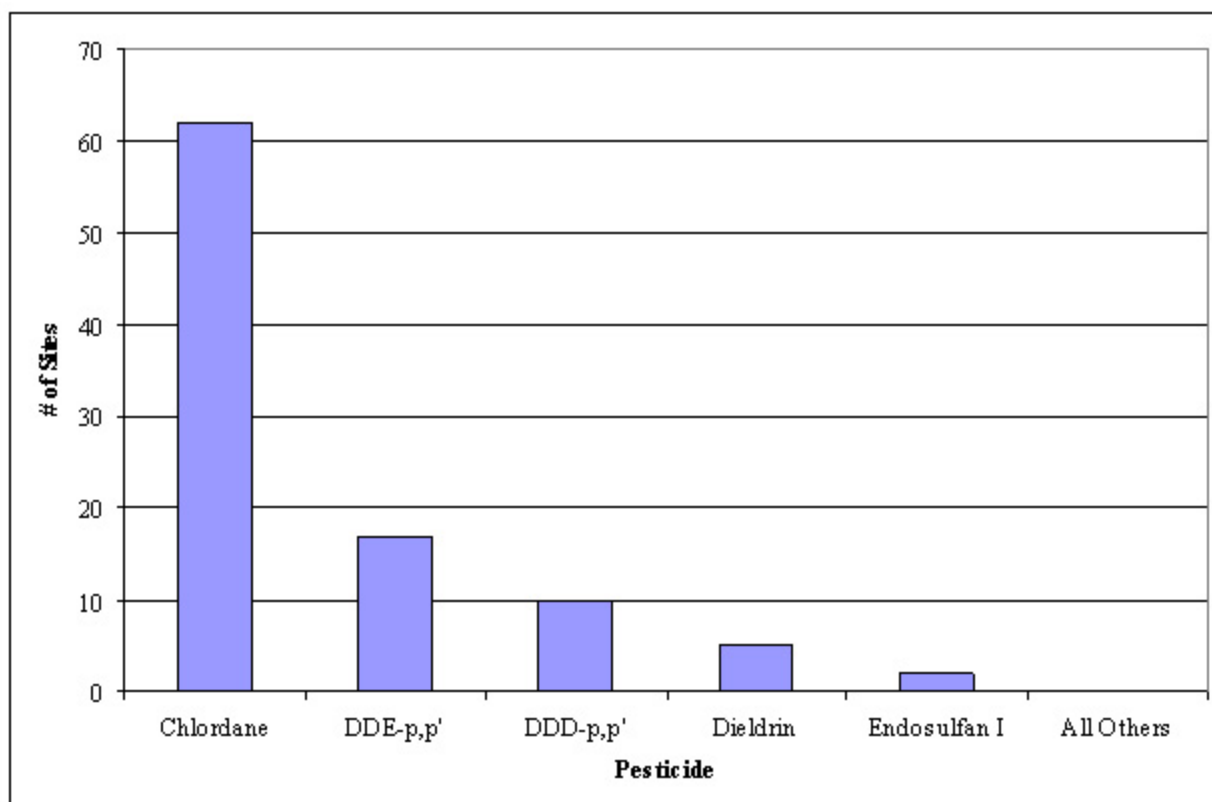
Individual samples were analyzed for 20 compounds listed in Table 1. Analysis was completed by the FDEP labs in Tallahassee - the organochlorines by GC/ECD (EPA 8080 mod) and the organonitrogens and phosphates by GC/NPD (EPA 8141A mod). Organic content was analyzed using a standard autoclave method.

Table 1. Compounds included in analysis of soil samples.	
Aldrin	Endrin Aldehyde
DDD-p,p'	Heptachlor
DDE-p,p'	Heptachlor Epoxide
DDT-p,p'	Methoxychlor
Dieldrin	Beta-BHC
Endosulfan I	Toxaphene
Endosulfan II	Delta-BHC
Endosulfan Sulfate	Gamma-BHC
Alpha-BHC	Chlordane
Endrin	Atrazine

Results

Occurrence of organochlorines in detectable concentrations was limited to Chlordane, DDE, DDD, Dieldrin, and Endosulfan I (Figure 3). Chlordane was the dominant pesticide, with 62 of the 134 sites exhibiting contamination. Thirteen out of 17 detectable DDE concentrations and 6 out of 10 DDD sites also had Chlordane residuals (Figure 4). All 5 of the Dieldrin sites also had Chlordane.

Raised planting areas exhibited a higher level of contamination in the first collection than in the



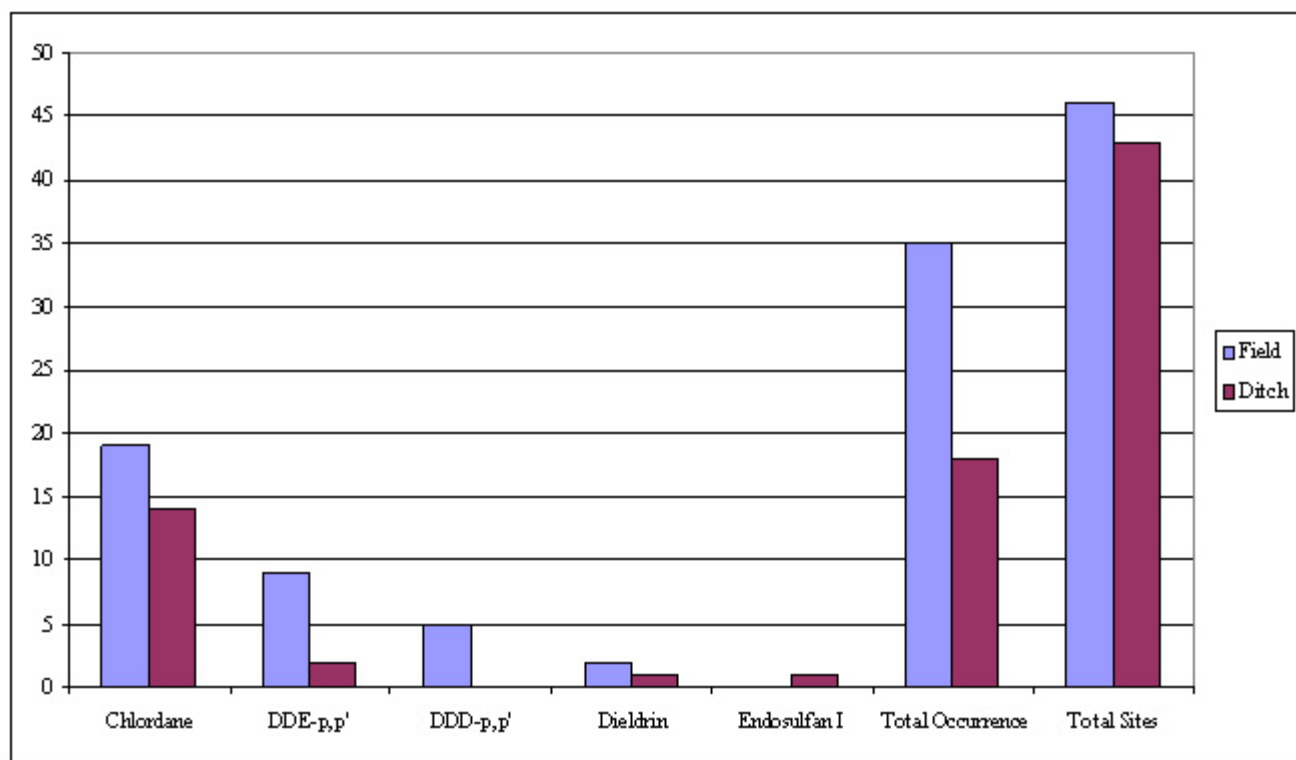
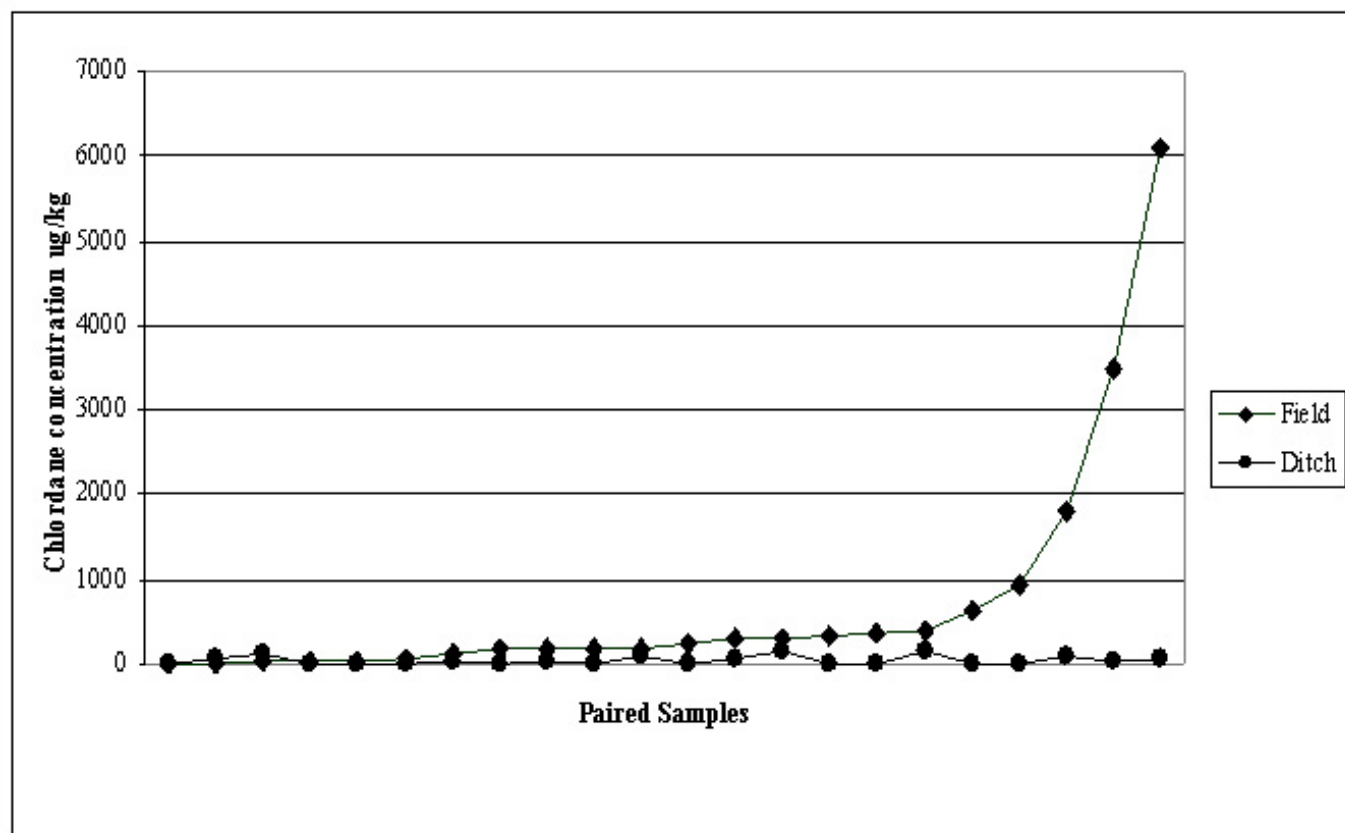


Figure 5. Comparison of pesticide occurrence in raised field areas and ditched or furrowed areas.



ditched or furrow areas, 76% for raised areas and 42% for ditches and furrows (Figure 5). However, where Chlordane was present, it occurred in both ditch and field areas. The average Chlordane concentration of field areas was significantly higher ($p=0.0024$) than ditched (Figure 6). The average concentration for all non-zero Chlordane sites was 454.01 ± 932.64 with a range of 3.1 to 6100 $\mu\text{g}/\text{kg}$. There was no correlation between the organic content of the soil and Chlordane concentrations.

In addition to chemical analysis of sediment samples, a qualitative evaluation of seasonal inundation was completed via helicopter and groundtruthing of contaminated sites in September, 2000. Although the annual rainfall for 2000 was below average, the lower Southern Golden Gates Estates area was intermittently flooded (Figures 7 & 8). However, the raised planting areas still remaining in the fallow agricultural areas were mostly above water, with inundation confined to ditches and furrows.

Figures 9 and 10 show a qualitative evaluation of spatial patterns connected with incidence of highest Chlordane concentration. Belle Meade fields show evidence of a single linear area of high residual concentration (Figure 9), while the SGGE area shows two high-level residual areas, with the highest concentrations of the two test areas (Figure 10). However, no clear pattern of contaminated sites at the environmental risk level is apparent.

Discussion

This study of residual pesticide in abandoned agricultural fields was intended as a preliminary assessment of the extent of contamination in watersheds with potential effects on RBNERR managed aquatic areas. Of the 20 substances tested for, Chlordane is the most significant contaminant requiring follow-up. Although not as toxic as Dieldrin, Chlordane and its derivatives can have serious negative environmental impacts, particularly on bird populations (Stansley and Roscoe 1998). Chlordane and its derivatives exhibited strong negative correlation with amphipod survival in studies conducted in Biscayne Bay at sediment concentrations below 150 ppb (Long et al. 1999). Chlordane has a bioconcentration factor of 3,000 to 12,000 in marine species and exhibited a biomagnification factor of 44.2 from fish to bear in one foodchain study (Syracuse Research Corporation 1994).

Levels of concern for concentrations of organochlorines in sediment samples have been adopted by Florida Department of Environment and environmental levels are presented in detail in the MacDonald Environmental Sciences, Ltd. Report (1994). Table 2 presents threshold effects levels (TEL) and probable effects levels (PEL) from that report for pesticides found in the study area. The Occupational Safety and Health Administration (OSHA), the National Institute

Table 2. Concentrations of Concern ($\mu\text{g}/\text{kg}$ or ppb)		
Pesticide	TEL	PEL
Chlordane	2.26	4.79
DDD	1.22	7.81
DDE	2.07	374
Dieldrin	0.715	4.30
Aldrin and Endosulfan not available		



Figure 7. Example of inundated furrows and dry raised areas in Souther Golden Gates Estates fallow agriculture fields.



Figure 8. Aerial shot of Southern Golden Gates Estates fallow agriculture fields.

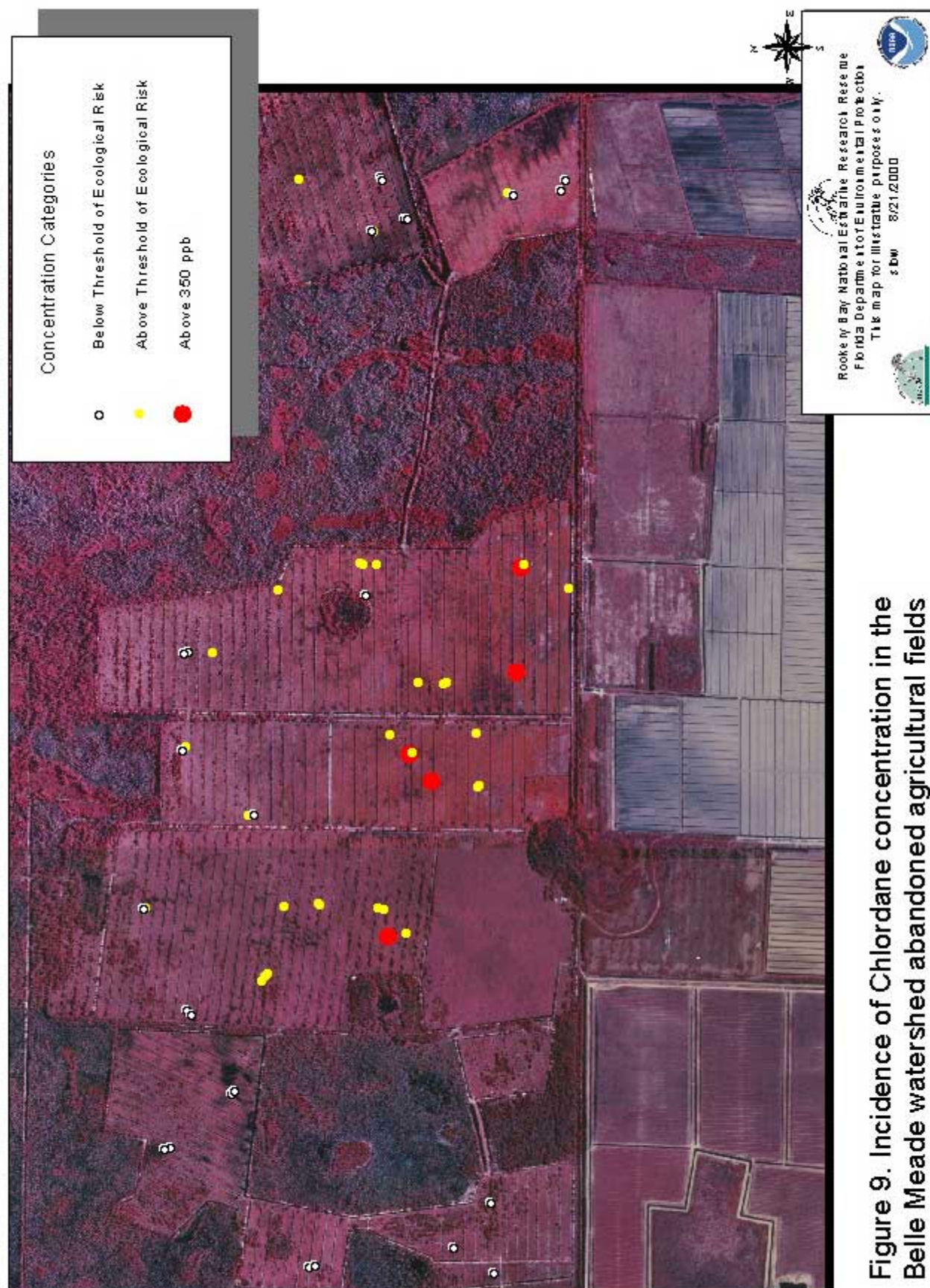


Figure 9. Incidence of Chlordane concentration in the Belle Meade watershed abandoned agricultural fields

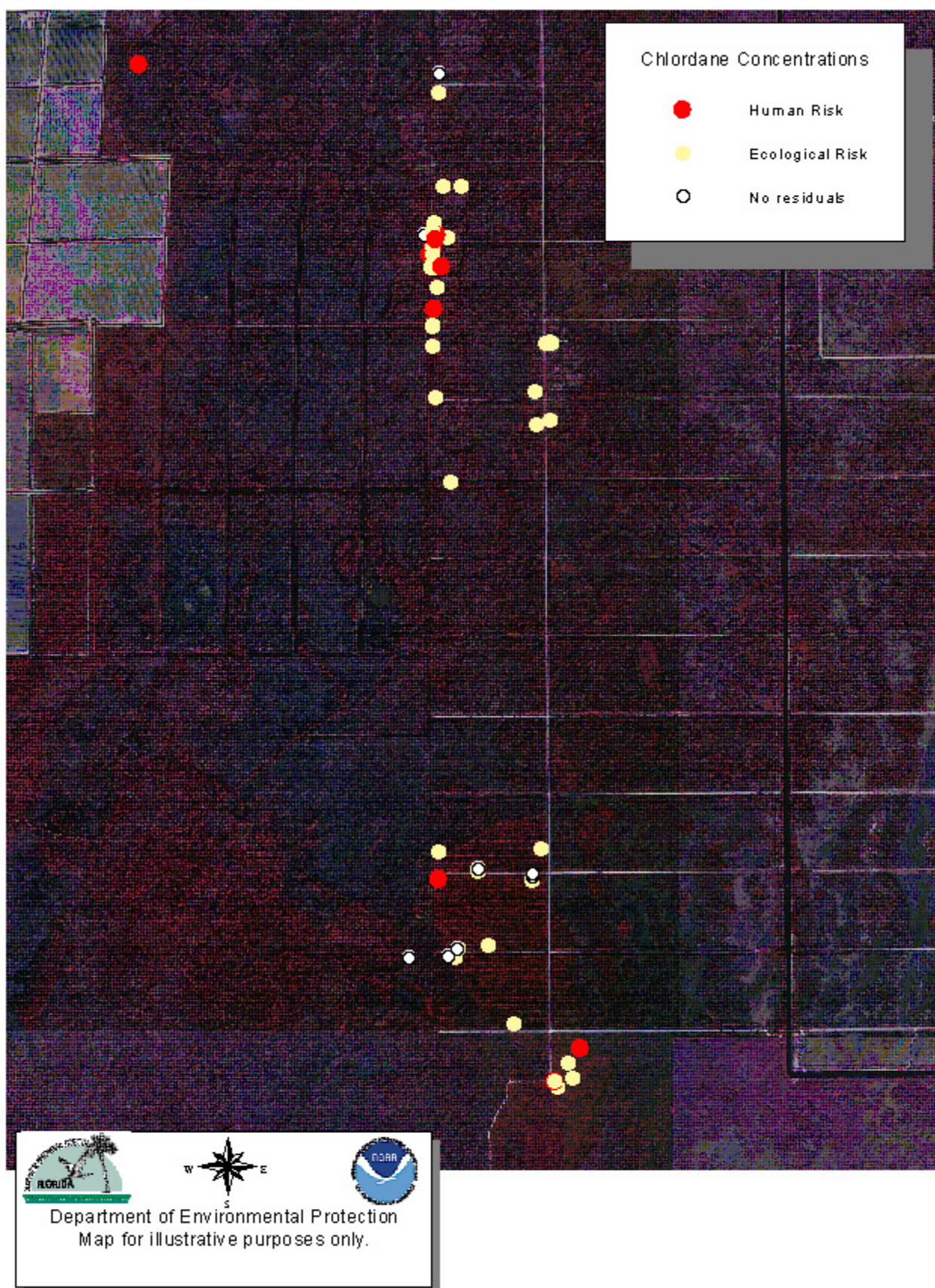


Figure 10. Incidence of Chlordane in the Southern Golden Gates Estates (Picayune Strand State Forest) abandoned agricultural fields

for Occupational Health and Safety (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH) set a maximum level of 0.5 milligrams of chlordane per cubic meter (mg/m³) in workplace air for an 8-hour workday, 40-hour workweek. They have further advised that eye and skin contact should be avoided since this may be a significant route of exposure (ATSDR 1994), but no dermal health guidance value has been established.

There is no localization of the Chlordane contamination in the Belle Meade and Picayune strand subbasins, and at least one non-agriculture site had a high Chlordane concentration (Figure 10). Chlordane is considered a “non-leacher”, remaining in the top 20 cm (the depth these sites were tested at), but shows transport with surface water movement from the top 2 cm (Syracuse Research Corporation 1994). Because the surficial water table is close to 15 cm from the surface much of the year in this area, potential contamination of the aquifer may have occurred.

The Southern Golden Gates Estates area is slated for hydrologic restoration in 2002, and requires an immediate recommendation on extent of area necessary for remediation prior to flooding. We recommend 100 to 200 more random sample sites throughout the western section of the Picayune Strand, concentrating on Chlordane analysis, but including Dieldrin since it has higher toxicity. FDEP (Division of Waste Management, Tallahassee) further recommends we sink a test well and take water samples prior to removing the contaminated soil. An analysis of contamination extent, at a sample size sufficient for rigorous statistical analysis, should be completed. A recommendation from FDEP for extent, depth and methods of remediation should be issued based on the larger sample size and incorporated into the Project Implementation Plan for the Southern Golden Gates Estates Restoration project.

References

- Agency for Toxic Substances and Disease Registry (ATSDR). 1994. Toxicological profile for chlordane (update). U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA.
- Exponent, 2000. Analysis of avian mortality at the north shore restoration area of Lake Apopka in 1998-1999, prepared for St. John's River Water Management District DRAFT Report.
- Long, E., G. Sloane, G. Scott, B. Thompson, R. Carr, J. Biedenbach, T. Wade, B. Presley, K. J. Scott, C. Mueller, G. Brecken-Fols, B. Albrecht, J. Anderson, G. Chandler, 1999. Magnitude and Extent of Chemical Contamination and Toxicity in Sediments of Biscayne Bay and Vicinity. NOAA Technical Memorandum NOS NCCOS CCMA 141, Silver Springs, Maryland.
- MacDonald Environmental Services. Ltd., 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters, Volume 1: Development and Evaluation of Sediment Quality Assessment Guidelines; prepared for FDEP, Tallahassee, Florida.
- Pfeuffer, R. J., 1991. Pesticide Monitoring in Sediment and Surface Water Within the South Florida Water Management District, Volume 2, Tech. Pub. 91-01, West Palm Beach, Florida.
- Pittman, C., 1999. Lake Apopka toxic stew blamed for bird deaths. St. Petersburg Times, March 18 1999.
- Stanley, W. and D. Roscoe, 1998. Chlordane poisoning of birds in New Jersey, USA. Environmental Toxicology and Chemistry 18:2095-2099.
- Syracuse Research Corporation, 1994. Toxicological profile for chlordane : update; by subcontract to Clement International Corporation under contract no. 205-88-0608; prepared for U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.